



## A case study of sea and shorebird breeding recovery following goat and cat eradication on Klein Curaçao, southern Caribbean

### Un estudio de caso de recuperación en la reproducción de aves marinas y playeras posterior a la erradicación de cabras y gatos en Klein Curazao, Caribe sur

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**ABSTRACT.** Here, we document major seabird breeding recovery on a satellite island of Curaçao in the southern Caribbean following the removal of goats in 1997, significant reforestation from 2000–2005, and the extermination of cats in 2001. The only seabird to have been confirmed to breed on the island since the 1960s and until recently has been the Least Tern (*Sterna antillarum*). However, we now confirm nesting for an additional eight sea- and shorebird species on the island for the first time based on field observations in 2021 and 2022. The total number of documented nesting pairs annually has increased from a maximum of 140 pairs (of a single species in 2002), to > 430 pairs (of all species combined) in 2021 and 650 pairs in 2022. The dominant species are the Cayenne Tern (*Thalassaeus sandvicensis*), Laughing Gull (*Larus atricilla*), Sooty Tern (*Onychoprion fuscatus*), and Least Tern, in that order. Breeding by the Sooty Tern and Bridled Tern (*Onychoprion anatheus*) are new national records for Curaçao. Klein Curaçao is now the island group's most diverse and active seabird breeding location. Major threats to the nascent recovery of seabird breeding in this Ramsar-designated wetland area are the growing and uncontrolled human recreation, the repeated threat of reintroduction of feral cats, and predation by rats. Recommendations are made on measures needed to address these threats. The case study of Klein Curaçao demonstrates the potential for seabird recovery when deleterious invasive mammals are eradicated from islands.

**RESUMEN.** Documentamos la recuperación mas grande en la reproducción de aves acuáticas en una isla satélite de Curazao en el caribe sur después de la remoción de cabras en 1997, reforestación significativa entre 2000-2005 y el exterminio de los gatos en 2001. La única ave marina que había sido confirmada reproduciéndose en la isla desde 1960 y recientemente era *Sterna antillarum*. Sin embargo, ahora confirmamos la anidación de ocho especies de aves playeras y marinas en la isla por primera vez, con base en observaciones de campo en 2021 y 2022. El número total documentado de parejas anidado anualmente ha incrementado de un máximo de 140 parejas (de una sola especie en 2002) a >430 parejas (de todas las especies combinadas) en 2021 y 650 parejas en 2022. Las especies dominantes son *Thalassaeus sandvicensis*, *Larus atricilla*, *Onychoprion fuscatus* y *Sterna antillarum*, en ese orden. La reproducción de *Onychoprion fuscatus* y *Onychoprion anatheus*, son registros nacionales nuevos para Curazao. Klein, Curazao, es ahora es la isla con la localidad de reproducción más diversa y activa para el grupo. Las mayores amenazas para la recuperación incipiente de la reproducción de aves marinas en este humedal designado como área Ramsar son el crecimiento y poco control de la recreación humana, la repetida reintroducción de gatos salvajes y la depredación por ratas. Realizamos recomendaciones en el tipo de medidas requeridas para manejar estas amenazas. El estudio de caso de Klein, Curazao, demuestra el potencial para la recuperación de aves marinas cuando los mamíferos invasivos deletéreos son erradicados de las islas.

**Key Words:** *cat eradication; conservation restoration; human disturbance; rat predation; reintroduction; seabird colony*

#### INTRODUCTION

Invasive mammals, including goats, cats, dogs, rats, mice, cattle, and others, have had devastating effects on island biodiversity and seabird breeding worldwide (Moors and Atkinson 1984, Hilton and Cuthbert 2010, Croxall et al. 2012). The eradication of these invasive populations is key to safeguarding such unique island biodiversity from further losses (Hilton and Cuthbert 2010, Croxall et al. 2012). Notwithstanding a few prime examples such as the eradication of black rats (*Rattus rattus*) from Monito Island, Puerto Rico, several small islands of Antigua and Barbuda (including Redonda), and Dog Island, Anguilla (Simberloff 2001, Daltry et al. 2012, Bright et al. 2014, Donihue et al. 2021), as well as the eradication of goats from Desecheo Island and Redonda (Figueroa-Hernández et al. 2017, Donihue et al. 2021), very few of the hundreds of invasive mammal eradication projects have been documented for the Greater Caribbean region.

Consequently, invasive mammals remain one of the most pervasive and persistent threats to island biodiversity and seabird breeding colonies throughout that region (Hilton and Cuthbert 2010, Figueroa-Hernández et al. 2017, Brooke et al. 2018, Coffey and Collier 2021), and action to eradicate invasive mammals and contain the threat they represent is of the highest priority.

Our aim was to document current seabird nesting on the coral island of Klein Curaçao, off the coast of Curaçao, Dutch Caribbean, since goat and cat eradications were successfully achieved on the island in 2001. Our case study of Klein Curaçao is indicative of the marine avifaunal recovery that becomes possible once such invasive mammals are removed and reflect similar results seen in successful eradications elsewhere. Hopefully, our results will serve to stimulate similar initiatives elsewhere in the Greater Caribbean region.

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## METHODS

### Study area

Klein Curaçao is a small, flat, and barren 130-ha coral island located approximately 10 km southeast off the main island of Curaçao. Together with the main island of Curaçao, it is part of the Dutch Caribbean and lies off the coast of Venezuela in the southern Caribbean Sea (Fig. 1). Today, the island consists of a low-lying limestone rock core with numerous karst sinkholes containing hypersaline to brackish water and is rimmed by ridges of coral debris and beach sand (Stienstra 1991). The southern half of the island is roughly dominated by a surface of loose, shallow soils overlying recent or subrecent coral shingle, beach rock, or ramparts; the northern half is dominated by lower terrace depositional limestone rock (de Buissonjé 1974). The northern cape of the island has a relatively large area of shallow pools, whereas the southern cape has a more limited area of shallow pools. The total length of the island is approximately 2.5 km, the maximum width is approximately 700 m, mean elevation is < 1 m, and maximum elevation is 4.7 m (Stienstra 1991). Mean temperature is 27.5°C, and average rainfall is 410 mm/yr, which is less than the average of 550 mm/yr for Curaçao as measured at the Hato meteorological station on the main island of Curaçao. Approximately 50% of rainfall occurs in October through December (Meteorologische Dienst Nederlandse Antillen 1982).

Until the mid-19th century, Klein Curaçao was 2–3 m higher and more vegetated, but it was subsequently lowered and flattened by mining for guano and was overgrazed by goats and sheep (Euwens 1926). Based on visits by Suringar in 1885 (Boldingh 1914) and Wagenaar-Hummelinck in 1936 (Wagenaar-Hummelinck 1940), the island has been devoid of bushes and trees for more than 100 years. The island is principally inhabited by the endemic omnivorous whiptail lizard, *Cnemidophorus murinus*, and large numbers of the West Indian hermit crab, *Coenobita clypeatus*. Among the invasive species present are rats, *Rattus cf. norvegicus*, a flock of approximately 40 House Sparrows, *Passer domesticus*, and (as of 2019) a single recently introduced, cared-for house cat, *Felis silvestris*. Boasting the longest sandy beach of Curaçao, this uninhabited island is a popular tourist destination and receives > 1000 visitors each week that are principally brought there by a number of commercial touring boats. Recreational disturbance is most intense around the three main anchorage sites on the mid- to southern half of the island.

In the historical past, conditions on the island were quite different. Not only was it minimally a hauling and possibly pupping site for the extinct Caribbean monk seal (Debrot 2000), it was also an important seabird rookery, most importantly for boobies (*Sula* spp.; Euwens 1926). Until the early 18th century, the birds were considered important to maritime navigation because they served as the only indication of land to mariners at a time when there was yet no lighthouse (Euwens 1926). Due to a combination of overharvest of eggs, extensive mining for guano from 1871–1913, and overgrazing by livestock, breeding boobies were already nowhere to be found by the early 20th century (Euwens 1926). The only seabird species for which Voous (1983) was able to confirm nesting were the Least Tern, *Sterna antillarum*, and the Cayenne Tern, *Thalassaeus sandvicensis* (Voous 1983). Although Voous (1983) also suspected some, albeit sporadic, nesting by the Laughing Gull, *Larus atricilla*, the Common Tern, *Sterna hirundo*,

and the American Oystercatcher, *Haematopus palliatus*, no breeding of these or other seabirds has since been confirmed for the island.

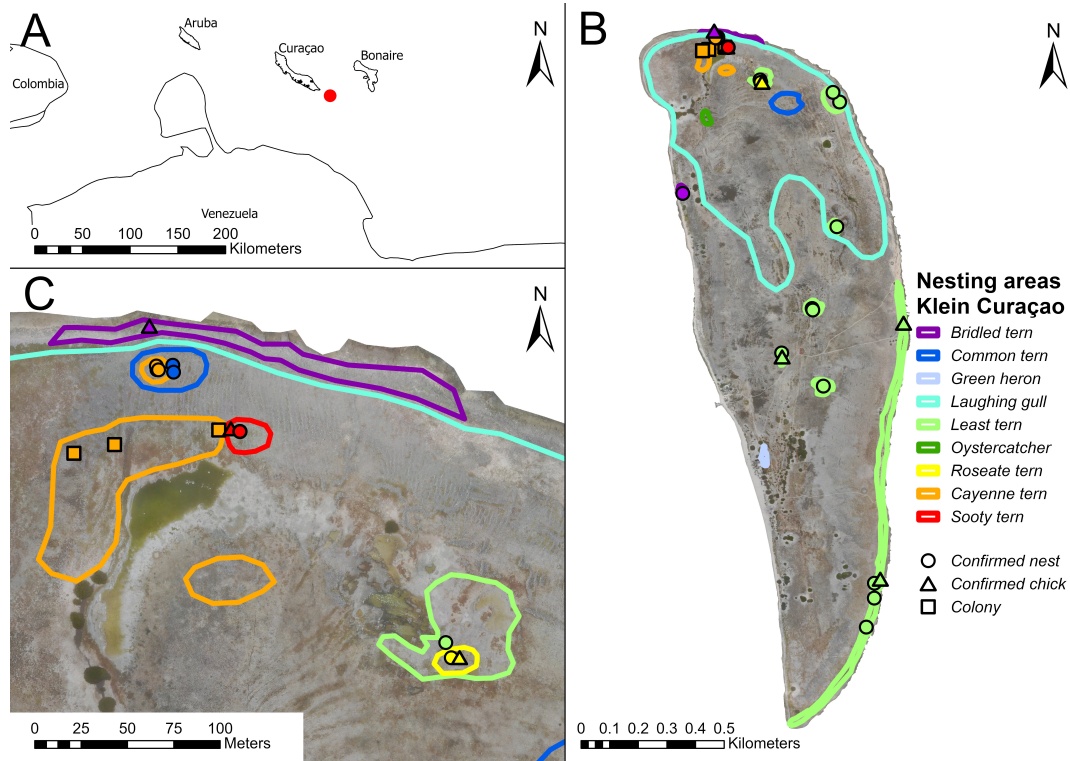
Feral goats were eradicated from the island in 1996 by the Curaçao Agriculture, Animal Husbandry and Fishery Service. During a visit in July 2001, the then vacant Least Tern colony was found littered with dead terns. Following this observation, feral cats were eliminated by Caribbean Research and Management of Biodiversity (CARMABI) in October 2001 (Debrot et al. 2009). These important eradications (of deleterious herbivores and predators) paved the way for gradual ecological recovery of the island as assisted (since 2000) by CARMABI through the planting of drought- and salt-resistant native trees, shrubs, herbs, and grasses (Debrot 2015). The reforestation (re-)introductions took place from 12 August 2000 to 16 November 2005. A combined total of 58 native plant species were taken from Curaçao to Klein Curaçao during the course of 15 day-trips. A total of 1174 individual saplings and potted plants, 482.7 kg of cuttings of succulents, and 124.7 kg of seeds, fruits, or cuttings of herbaceous plants were introduced (Debrot, *unpublished data*). As of mid-2022, the total flora present amounted to approximately 54 species, of which only 10 native herb and grass species were present prior to the reforestation effort, 2 species were introduced ornamentals, and 2 species were recently arrived non-intentionally introduced invasive weeds. Many of the 40 still-surviving (re-)introductions have been spreading naturally over the island and have led to large-scale landscape-level changes (Debrot 2015; Fig. 2).

Corroborating Voous' (1983) findings, Debrot et al. (2009) documented nesting by the Least Tern as an annual occurrence (up until 2000), but were unable to document any other sea or shorebird breeding species. In the meantime, based on its global importance as a nesting island for the Least Tern, the island was designated as an Important Bird Area (IBA) by BirdLife International in 2008 (Debrot and Wells 2008). In 2018, it was designated as a Ramsar wetland based on the combination of its IBA status, sea turtle nesting (Debrot et al. 2005), and healthy coral reefs (WAIIT Institute 2017).

### Nesting surveys

Two years of weekly avifaunal assessments were done on Klein Curaçao during January through December of 2021 and 2022 by coauthors Wellens and de Vries, who were occasionally also accompanied by coauthors Pors-da Costa Gomez, Rusch-de Lijster, and Cijntje. All significant avifaunal sightings and photographs were submitted to the [eBird.org](https://eBird.org) online database. The exact times during which surveys were conducted depended on the sailing schedule of the touring vessel *Mermaid* and generally took place between 9:30 am and 2:00 pm. During the height of the 2021 breeding season, Wellens stayed on the island overnight one day each week for a period of three months (July, August, and September) to monitor birds (and rat activity) by night and during dusk. De Vries concentrated her efforts on the Least Tern. Trail cameras (Bushnell Model 119977C) were used to monitor nesting activity of the Laughing Gull, Cayenne Tern, and Least Tern. Sooty Terns and Bridled Terns were also monitored, both of which are often most active at their nests at dusk or at night, and are often away from their nests during the day (Harrington 1974, Hulsman and Langham 1985, Dunlop and Jenkins 1992).

**Fig. 1.** (A) Map showing the location of Klein Curaçao (red circle), located east of Curaçao in the southern Caribbean Sea. (B) Map of Klein Curaçao, showing the distribution of documented nesting for nine species across the island in 2021 and 2022. (C) Details of bird locations at the northern tip of the island (C).



**Fig. 2.** Photos of recent landscape changes following goat eradication and reforestation on Klein Curaçao. (A) The barren aspect of the island prior to goat eradication, as photographed in 1990 (Photo courtesy N. Wijnen). (B and C) Examples of the state of landscape diversification in 2021, 16 yr after the last plant (re-)introductions in 2000–2005 (Photos: A. Debrot).



In 2022, GPS coordinates were taken for key record locations to allow additional documentation. Starting in 2022, rat poison (Klerat© 20-g wax blocks with 0.005% of the anticoagulant brodifacoum) was deployed at selected tern nests.

## RESULTS

### Species accounts

#### *American Oystercatcher, Haematopus palliatus*

American Oystercatchers were present on the island year-round. In 2021 and 2022, respectively, one and two pairs nested on Klein Curaçao. Nesting-related territorial and diversion activities were first observed on 30 March 2021 and 23 March 2022, respectively, while fully-fledged young were photographed on 22 June 2021 and 28 June 2022. The fledgling from 2021 was seen together with its adults for a very long time and remained present into May 2022.

#### *Green Heron, Butorides striatus*

One to possibly two Green Heron fledglings were observed amongst dense buttonwood, *Conocarpus erectus*, scrub on 6 and 13 July 2022 at approximately 5 m from where an empty Green Heron nest was found on 19 October 2022. The nest was well-hidden in the dense brush approximately 2 m above water. On 27 July 2022, an adult bird was observed around the pools around the nest, and on 19 October 2022, one wary adult was seen approximately 150 m south of the nest.

#### *Laughing Gull, Larus atricilla*

The first birds arrived on the island in February and into breeding habitat in March. In 2021, an average of 150 adult birds produced an estimated 100–150 chicks. In 2022, approximately the same number of Laughing Gulls produced an estimated 150–200 chicks. All breeding activity was concentrated on the northern half of the island (Fig. 1). Chicks, when small, would hide between rocks during the day, and were only seen wandering about during the heat of day when they were bigger. During breeding and while the chicks were not yet flying, the parents vigorously defended nests and chicks. By late June, fledglings were up and about.

#### *Bridled Tern, Onychoprion anathus*

In 2021, this species was present from 4 May through the first half of September, totaling approximately eight birds. Breeding was strongly suspected, but no eggs or chicks could be confirmed in 2021. In 2022, the first Bridled Terns were spotted during daylight on 28 June. Breeding was again suspected based on the behavior of three pairs, which were clearly nervous when approached, and on 18 August 2022, the first chick was observed hidden between rocks. The parents and chick kept appearing on the nocturnal trail cameras through 27 September 2022.

#### *Sooty Tern, Onychoprion fuscatus*

Although Sooty Terns were closely followed during the 2021 breeding season, there was no definitive proof that breeding occurred. Numbers remained few, with a peak abundance of 23 birds on 22 June 2021. Numbers observed were much greater during the 2022 breeding season, ranging to as many as 150–200 birds mid-June 2022, and on 13 July 2022, a nest with a chick was confirmed. A week later, 20 July, a second nest with one egg was found. On 10 August, the egg of a second nest had hatched, and a chick was observed in the nest. A trail camera in the vicinity also showed the nocturnal presence of rats. While the chick was not detected again after 10 August, the adults continued to visit the site nocturnally until 31 August 2022, after which they were not seen again.

#### *Cayenne Tern, Thalassaeus sandviscensis*

The number of Cayenne Terns present during the 2021 breeding season was approximately 150 birds, and breeding was observed, with 10 nests with eggs being found. The birds nested in one larger colony (with approximately nine pairs confirmed with eggs) and one smaller colony. All breeding activity was concentrated on the northern half of the island (Fig. 1). Rats were observed on trail cameras to have taken eggs the night immediately after they were laid. All of the nests monitored lost all their eggs. In early May 2022, approximately 200 Cayenne Terns started arriving at the breeding locations, which number quickly grew to > 1000 birds by 1 June 2022. In total, four breeding groups formed, the largest one occupying an elevated area to the northeast of the northern pools of the island. There, a maximum of approximately 1000 mature birds with chicks was present by the middle of June. By the end of the month, hundreds of chicks could be seen around the pools. By mid-July the large breeding colony was empty, with chicks still grouped in creches. On 20 July 2022, the first fledglings were seen flying. Additionally, on 25 May 2018, a small group of eight nesting Cayenne Terns were photographed on the northeast side of the island, and three eggs could be counted, confirming nesting effort in at least one season prior to our study (Da Costa-Gomez, *personal observation*).

#### *Roseate Tern, Sterna dougalli*

Although up to six Roseate Terns in breeding plumage were seen during the 2021 season, and two adults and a flying fledgling were observed on 14 July, we obtained no definitive proof that breeding occurred on Klein Curaçao during the 2021 breeding season. However, on 18 May 2022, a nest with one egg was found. Both parent birds were seen taking turns incubating the egg. On 15 June, the chick was observed in the nest. The trail camera at the site showed the chick moving around on top of a large rock sheltering the nest on 18 June. The parents remained in the vicinity of the nest for the next two weeks, and the fledgling itself was last observed near the nest on 20 July 2022.

#### *Common Tern, Sterna hirundo*

The number of Common Terns present on Klein Curaçao during the breeding season was quite low. A maximum of ten terns was counted on 9 April 2021, and during the actual breeding season, the number never topped six. No chicks were seen, and rat presence was heavy in the area. In 2022, the number of Common Terns followed the results of 2021 closely, with never more than 12 birds seen on any given day. In 2022, the first nest with two eggs was found on 18 May, and on 8 June, the first chick was observed very close to its nest, and a second chick was detected. By 1 June 2022, a total of three nests had been found close to each other, the second and third one likewise with two eggs each, and rats were documented on the trail cameras. The last time a chick was observed was on 28 June, when it was seen together with two adults, far from any nest. By 13 July 2022, one final nest remained, with both parents sitting on the eggs. Two weeks later, the nest was empty, and no birds remained in the area.

#### *Least Tern, Sternula antillarum*

Total colony size for the Least Tern for both 2021 and 2022 was approximately 35 pairs. Arrival of the species was in early April. First eggs were detected in early May, and fledging took place by mid- to late June. In contrast to the other terns, Least Terns did not clump together and often shifted their chosen nesting spots. In the past, when only Least Terns nested on the island, they almost exclusively nested on the northern half of the island (Debrot, *personal observation*), but during our study, they nested principally in the more open southern half of the island (Fig. 1) with less shelter availability, greater exposure to human disturbance, and fewer water pools for refreshment.

#### **Overall findings**

In this work, we document some remarkable milestones in the recovery of seabird breeding for the small, uninhabited island of Klein Curaçao in the southern Caribbean, following goat and cat eradication. The key developments in seabird breeding activity can be summarized in terms of two main findings. Firstly, documented sea and shorebird breeding activity since the 1960s (and through 2013), has increased from one to nine species, two of which are first records for Curaçao.

Secondly, the maximum number of documented nesting pairs annually (of all species combined) has increased from a maximum of 140 pairs (of one species in 2002), to > 430 pairs (of all species combined) in 2021 and 650 pairs in 2022. Although Least Tern breeding was down from approximately 140 in 2002 to approximately 35 pairs annually for 2021 and 2022, the Laughing Gull bred in both years, with approximately 75 pairs, while the Cayenne Tern had approximately 230 breeding pairs in 2021 and

500 in 2022. The number of Sooty Terns breeding, or attempting to do so, increased from 9 pairs in 2021 to between 40 and 45 pairs in 2022. The other four species had only a few nesting pairs each.

The timing of arrival and nesting and their distribution on the island differed among the species. The first species to nest was the American Oystercatcher. Laughing Gulls, which arrived in early March, were next. The Cayenne Tern, the Common Tern, and the Least Tern arrived practically together in April. These species were followed by the Roseate Tern arriving between April and May, and finally, the Sooty and Bridled Terns, which arrived in May and June. The most widespread nesting species was the Laughing Gull, which was found nesting loosely scattered across most of the northern half of the island. The four other larger terns also nested on that half of the island, as did the American Oystercatcher. The southern part of the island was almost exclusively used by the Least Tern, and the single documented Green Heron nesting also took place there. Hence, overall, most nesting activity took place on the northern half of the island.

## DISCUSSION

The massive impact of invasive mammals on breeding seabirds and island biodiversity worldwide have been extensively documented, and numerous studies point to the need for and benefits of eradicating invasive mammals from seabird breeding islands. In this respect, the Caribbean region lags notably behind (Hilton and Cuthbert 2010, Coffey and Collier 2021). The southern Caribbean, in particular, is of special region-wide seabird significance (Van Halewijn and Norton 1984, Wells and Wells 2006, Debrot et al. 2009, 2019), in part because of the combined presence of many isolated and uninhabited islets and keys for seabird nesting, as well as being the biologically most productive part of the Caribbean Sea due to seasonal upwelling off the coasts of Venezuela and Colombia (Castellanos et al. 2002, Rueda-Roa and Muller-Karger 2013).

Nogales et al. (2004) reviewed priorities in worldwide cat eradications, of which 83 have so far been documented (Campbell et al. 2011). Although a number of island rat eradications have been conducted in the Caribbean and goat eradications have been documented for two islands, aside from Klein Curaçao, no other cat eradications have yet been conducted. Hence, along with the few other studies done, the case of Klein Curaçao illustrates the potential results for seabird recovery elsewhere in the region, once goats and cats are eradicated. We hope our experience will serve to stimulate similar initiatives elsewhere in the region.

The only two sea or shorebird species that were ever previously confirmed as breeding on Klein Curaçao are the Least Tern and the Cayenne Tern (Voous 1983, Pors-da Costa Gomez and Pors 2021). The Least Tern has consistently bred there annually since at least 2000 (Debrot, *personal observation*). The most recent estimate available is for slightly more than 140 pairs nesting in 2002 (Debrot et al. 2009). The estimates obtained for 2021 and 2022 are considerably lower and suggest for these two years a somewhat reduced importance of Klein Curaçao as a nesting location for this species. In addition, compared to observations made by Debrot from 2000 through 2013, the Least Tern has largely shifted nesting to the more open southern part of the island, with less shelter availability and fewer water pools for refreshment. We speculate that this shift could partly be in response to the larger bird species usurping the choicest habitat.

The Cayenne Tern has not been documented as nesting on Klein Curaçao for more than 50 years, since the 1960s (Voous 1983). While since then, this species has continued to nest at various locations in neighboring Aruba and Bonaire (Prins et al. 2009), it has not been recorded from any other location in Curaçao until now. Hence, its breeding in large numbers for two consecutive years on Klein Curaçao is an important new development. Because all of its former nesting locations in Curaçao have succumbed to excess human disturbance (Debrot et al. 2009), it is of paramount importance to ensure that the nesting areas on Klein Curaçao are managed to remain free of human disturbance. Although the island is uninhabited, hundreds of day visitors frequent the island weekly, and their uncontrolled movement across the island represents a major threat that needs to be addressed. Whereas the deadly risk of cat predation has already largely been resolved, rats remain a predator of concern that we have now documented to be active in the breeding areas at night. Fortunately, for the large and aggressive Cayenne Tern, which nests together in dense colonies, rat predation seems to be somewhat less of a threat than for the smaller, less-gregarious species, where the rats were mostly documented.

The Laughing Gull has long been suspected as breeding on Klein Curaçao (Prins et al. 2009) but, until now, it has never been confirmed. Its confirmed presence, breeding in significant numbers for two consecutive years, is a major new development (Pors-da Costa Gomez and Pors 2021). Although the species is known to breed in significant numbers in nearby Aruba and Bonaire (Prins et al. 2009), in Curaçao, numbers breeding simultaneously have been strongly reduced since at least the 1960s due to human disturbance (Debrot et al. 2009). Notwithstanding the presence of rats, this species is able to breed successfully, possibly due to its size and aggression, with which it may be partially successful in warding off rats.

Although nesting by the American Oystercatcher, Green Heron, and the four less abundant terns (Bridled, Sooty, Roseate, and Common Terns) is numerically unimpressive, they are nevertheless important and unique developments for the island of Klein Curaçao. The American Oystercatcher is known to breed in small numbers on Aruba and Bonaire (Wells et al. 2017) but has not yet been truly confirmed for any part Curaçao (Pors-da Costa Gomez and Pors 2021). Our observations represent the first confirmation for breeding in small numbers for the territory of Curaçao. Finally, breeding by the Green Heron, which has been documented in many areas for the main island of Curaçao (Voous 1983), has never before been documented for Klein Curaçao.

Within the Dutch Caribbean, breeding by Bridled Terns and Sooty Terns has so far only been documented for the neighboring island of Aruba (Prins et al. 2009, Wells et al. 2017). The nesting of these species on Klein Curaçao are first records for the territory of Curaçao. As these species are small, less aggressive, nest in smaller numbers, and were observed to have times when they did not attend their nests or chicks, they seemed to be more vulnerable to rat predation. The same vulnerability to rats likely holds for the Common Tern and Roseate Tern, both of which (so far) only nest in very small numbers on Klein Curaçao. Both of the latter have been recorded from different small bay island sites in Curaçao in the past (Prins et al. 2009, Wells et al. 2017) but are new nesting records for Klein Curaçao.

## CONCLUSION

We conclude by pointing out several apparent threats to these encouraging sea and shorebird nesting developments and by making some minimal recommendations with which to address them. Firstly, we credit the increased abundance and diversity of seabird nesting we documented for Klein Curaçao principally to the removal of cats. Such trends in increased seabird breeding is expected upon removal of cats, even in situations where rats remain a problem (Hughes et al. 2008). Cats can be extremely lethal to nesting terns. Hughes et al. (2008) found cats (approximately 100 in number) killing adult Sooty Terns at an average rate of 33 individuals/night in large breeding colonies on Ascension Island. However, after eradication of cats, mortality due to predation on adult birds completely stopped even though rat predation on chicks continued (Hughes et al. 2008). Prior to the extermination of cats on Klein Curaçao in 2001, the Least Tern breeding colony was found littered with tern remains (Debrot, *personal observation*); such has not been observed since the cats were exterminated. To allow this protected Ramsar wetland IBA to regain its former importance as a seabird breeding island, it is essential to guarantee the absence of cats at large and to conduct regular removal of any cats brought to the island.

Secondly, direct predation by rats is often more difficult to document than predation by cats (e.g., Terpstra et al. 2015, Madden et al. 2020). However, rats were found to be widespread on the island and persistent in the nesting areas, as documented by our nocturnal trail camera footage. When rats were present, egg and chicks disappeared, but we did not succeed in video-recording rats carrying eggs, portions of eggs, or chicks away from nests. Whereas cats consume birds of all ages, rats tend to focus on eggs and chicks (Buxton et al. 2014). Hence, while removal of cats may especially influence breeding activity, removal of rats can be expected to improve breeding success greatly (Buxton et al. 2014). For better and more lasting results, the removal of rats (Dilley et al. 2017) should be pursued as a priority for Klein Curaçao. Given how rats have been found to prey on seabird eggs and chicks in situations comparable to Klein Curaçao (Hughes et al. 2008), we urge at least seasonal rat control by means of poisoning during the tern breeding season.

Finally, nesting terns can be very sensitive to recreational disturbance (Debrot et al. 2009, Croxall et al. 2012, Coffey and Collier 2021), which today amounts to > 600 recreational day visitors per week. To limit and control excess human disturbance, we recommend: (1) the placement and maintenance of signage for public information and awareness, (2) the prohibition of unleashed pets at all times, (3) the full closure of the northern half of the island to recreation except when accompanied by designated seabird guides, and (4) the cooperation of tour operators in informing their guests of the rules and in controlling their adherence to access- and pet-related rules.

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## Data Availability:

*The bird sightings on which this manuscript are based are fully accessible at <https://doi.org/10.13140/RG.2.2.10788.65920>.*

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